THE WEATHER AND CIRCULATION OF FEBRUARY 1960

A Cold Stormy Month Over the United States Associated With Widespread Blocking

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1. THE WINTER SEASON

Intense blocking over North America in February was the climax of the winter season of 1959–60. In the three months of December, January, and February the patterns of circulation (fig. 1A), precipitation (fig. 1B), and temperature (fig. 1C) had large departures from normal.

The 700-mb. mean pattern for winter 1959–60 consisted of a ridge in western North America and a trough in eastern United States. Most impressive was the positive height departure from normal (hereafter referred to as DN) which reached from 40° N. to beyond the North Pole, with a center of +480 feet near Baffin Island. To the south heights were lower than normal from 40° N. to southern Mexico, a pattern typical of blocking [1].

Precipitation in the winter of 1959–60 (fig. 1B) was more than 1½ times the normal in a band from the Southwest to the Great Lakes. Relative dryness was confined to parts of the Ohio Valley and the Pacific Northwest in an otherwise rather wet map.

The departures from normal of average surface temperature (fig. 1C) were well correlated with the 700-mb. height DN (fig. 1A) and resulted from successively colder months through the season. The onset of the calendar winter was a marked contrast to the cold fall season which had preceded. December was very mild (see fig. 4 of [2]); January was considerably colder (see fig. 7A of [3]); and in February (fig. 2) there was a further increase in the intensity and extent of the cold air.

In summary the winter of 1959–60 was cold in the South and warm in the North. The season began predominantly warm and ended with a very cold February. The circulation over North America featured high latitude blocking, which in the month of February played a most interesting role.

2. THE MONTHLY MEAN CIRCULATION

The predominant feature of the circulation in February, as shown in figure 3, was the large center of positive height DN over northern North America. The maximum height departure was 660 feet near Davis Strait, and heights averaged above normal from the Great Lakes to the North Pole and from the Gulf of Alaska to the Norwegian Sea. The impact of these anomalies was of primary significance to much of the western portion of the Northern Hemisphere and especially to the weather in the United States.

The area of positive height DN was surrounded by a band of negative departures which was almost uninterrupted around the hemisphere. That particular configuration was accompanied by an expanded circumpolar vortex of the classic type [4].

A further manifestation of the southward displacement of westerlies can be derived from the profile of zonal wind speed at 700 mb. (fig. 4). The belt of westerly winds reached a maximum of almost 15 m.p.s. at latitude 30–35° N. and remained stronger than normal down to 20° N. Normally the maximum has a speed 2 m.p.s. slower than and a location 5° north of that observed this February. Note also that the westerlies were about 8 m.p.s. slower than normal in the latitude band 50–55° N., compensating for the excess westerlies in lower latitudes [1].

The time variation of the 5-day mean zonal index, giving the speed of the 700-mb. temperate westerlies (35–55° N.) from 5° W. westward to 175° E., is reproduced in figure 5 for the entire winter season. Its general trend was downward, interrupted at mid-February by a temporary recovery. Weaker than normal temperate westerlies are frequently a sign of colder than normal temperatures at mid-latitudes over continents, as was observed in February (fig. 2). In addition, below normal thicknesses from 1000 to 700 mb. (fig. 6) were almost everywhere distributed in a manner similar to height departures from normal (fig. 3).

By the end of February the 5-day mean index fell to 5.1 m.p.s., the lowest value of the month and of the season. Five-day mean temperatures were also the lowest of the season at the end of the month when they averaged from 25 to 32° F. below normal from eastern Kansas to Idaho. In general, the long-term trend of the index was downward and very much like that of the surface temperatures in the United States for the winter season.

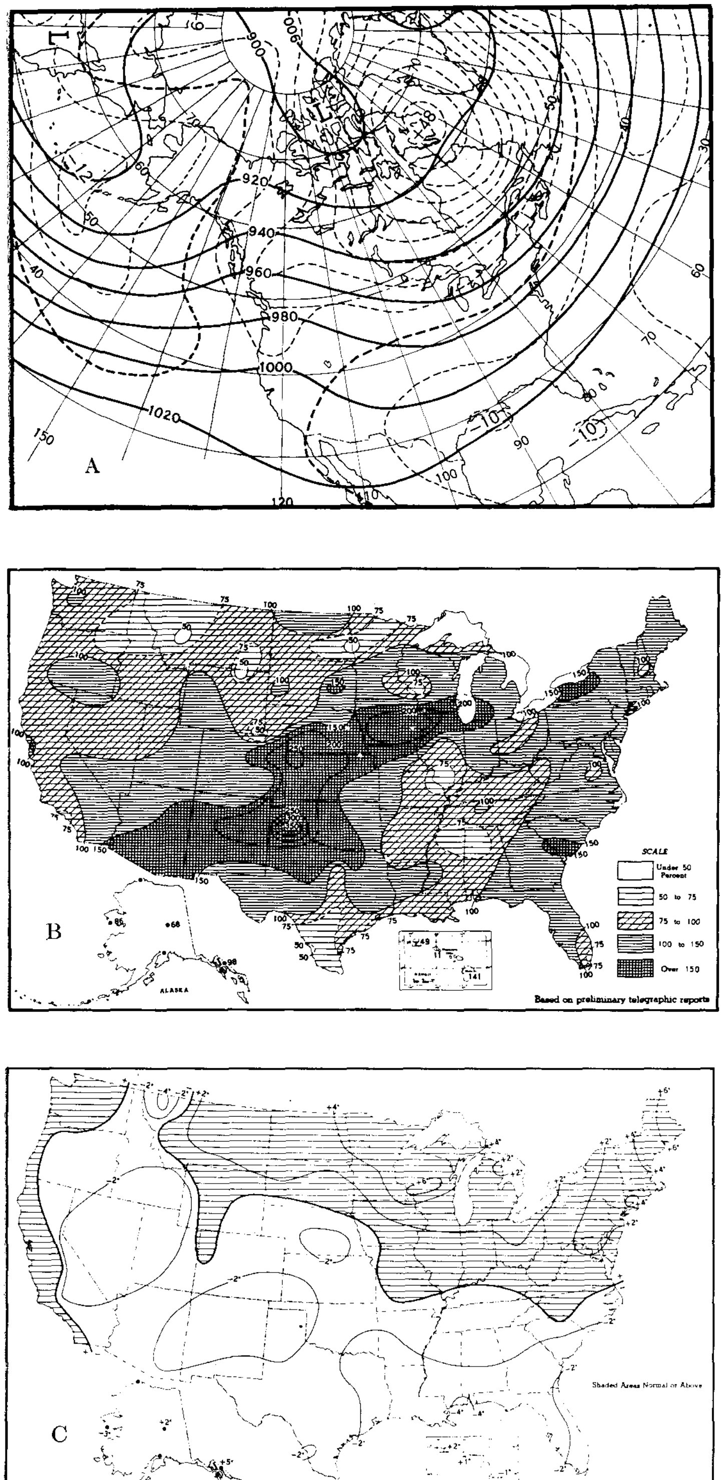

FIGURE 1.—(A) Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for December 1959–February 1960. The large positive height anomaly in Canada helped define the strong blocking. (B) Percentage of normal precipitation for December 1959–February 1960. Excessive precipitation was widespread and related to numerous daily storms south of the block. (From [8].) (C) Temperature departure from normal (°F.) for December 1959–February 1960. Note the warmth in the North and cold in the South. (From [8].)

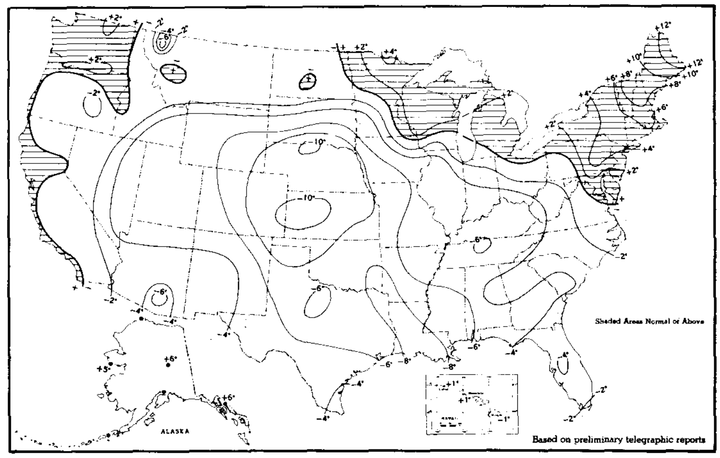

FIGURE 2.—Temperature departure from normal (°F.) for February 1960. Repeated invasions of cold air caused temperatures to average as much as 10° F. below normal in the Central Plains States. (From [8].)

The observed tracks of daily cyclones are illustrated in Chart X of [5] and should be compared with the observed 30-day mean sea level and DN chart (fig. 7). In the Pacific the Aleutian Low and subtropical High were close to their normal positions [6] since that ocean was affected little by the blocking over North America. In the Atlantic, however, the storm tracks were depressed southward, as were the 700-mb. westerlies. There blocking was quite noticeable since sea-level pressures south of 45° N. were less than normal with a maximum departure of −11 mb. near the Azores. The 1004-mb. Low just west of the United Kingdom was evidence of the great displacement of the Icelandic Low, normally located near Cape Farewell, Greenland.

In the United States the Southeast is normally under the influence of a mean High at sea-level. In February, however, that area had an average sea-level pressure as much as 6 mb. lower than normal and was subject to a mean flow from the north (fig. 7). There was an appreciable increase in the frequency and intensity of storms in the eastern United States compared to a long term average [7]. The procession of cyclones east of the Rockies and the frequent occurrence of cold ridges at sea level (see mean ridge in fig. 7) led to a cold, snowy February for much of the Nation.

3. MONTHLY MEAN WEATHER

Monthly mean temperature anomalies in the United States during February (fig. 2) were defined, to a great extent, by the blocking over eastern Canada (fig. 3). Colder than normal temperatures prevailed in at least three-fourths of the country. Negative departures from normal averaged 8 to 10° F. from the Central Plains to the Gulf Coast. In contrast, portions of the northeastern quadrant were above normal with a maximum of +12° F. in Maine.

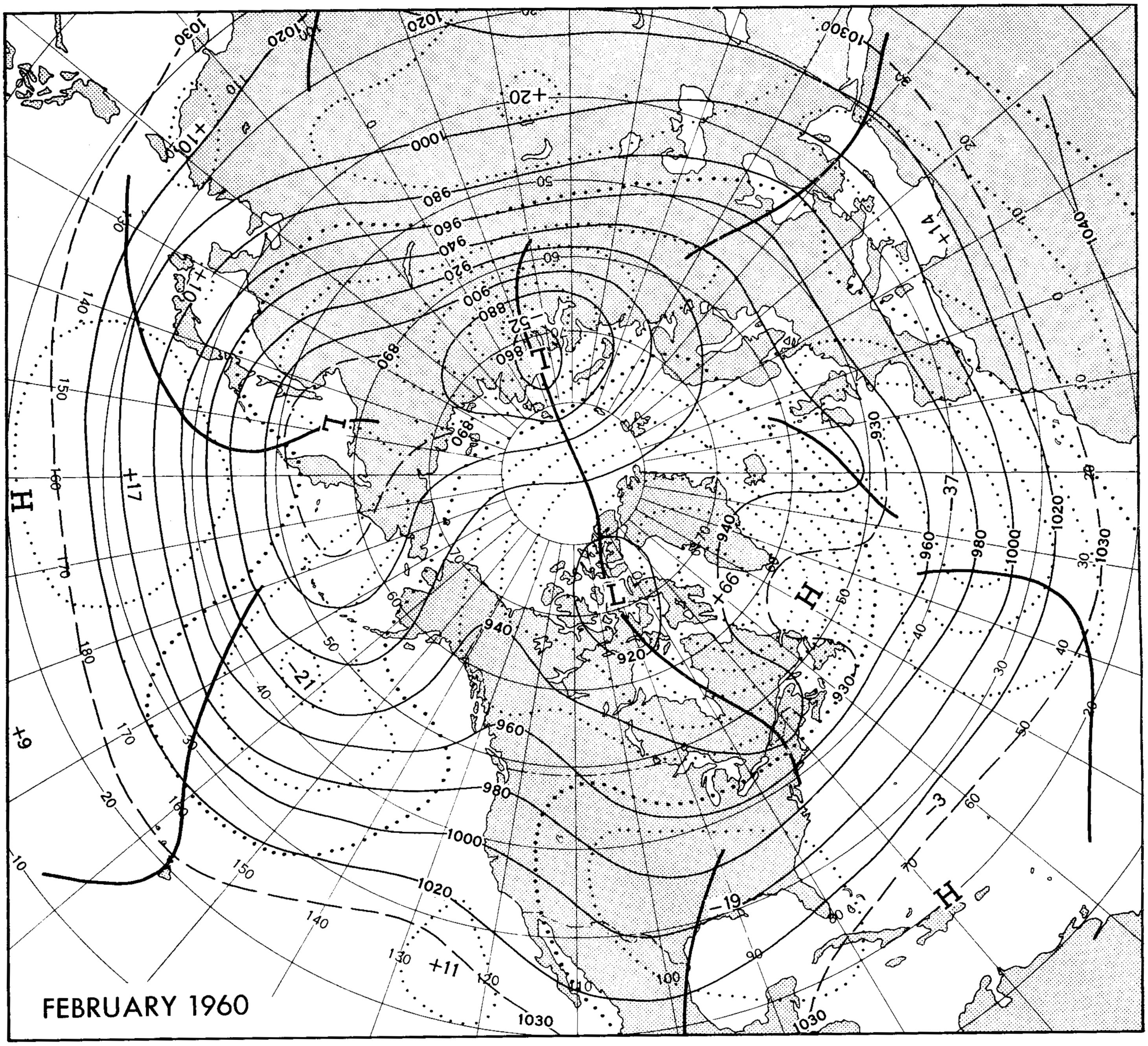

FIGURE 3.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for February 1960. Heavy solid lines are minimum latitude troughs. The expanded circumpolar vortex and high latitude blocking are emphasized particularly well by the height departures.

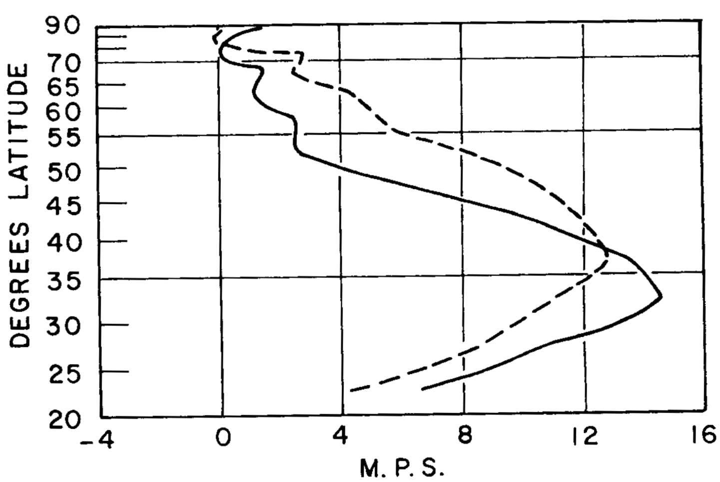

FIGURE 4.—Mean 700-mb. zonal wind speed profiles in the western portion of the Northern Hemisphere for February 1960 (solid) and February normal (dashed). The belt of maximum wind was displaced south of normal as a result of the blocking.

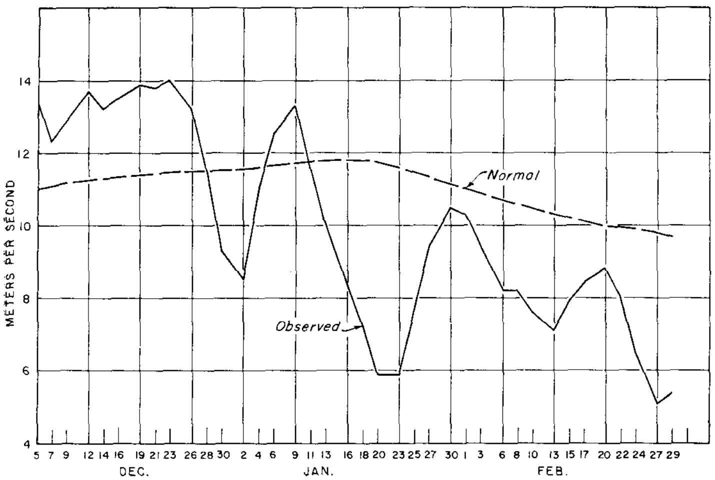

FIGURE 5.—Time variation of zonal index in meters per second for the western portion of the Northern Hemisphere in the latitude zone 35-55°N. The downward trend of the zonal index during the 1959-60 winter season was accompanied by a similar trend of temperature. The lowest index value in February and the coldest 5-day mean temperatures occurred at about the same time.

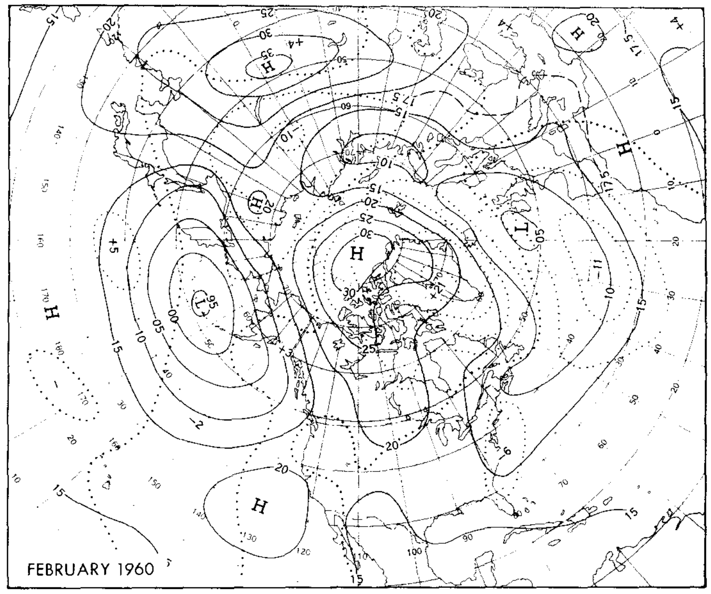

FIGURE 7.—Mean sea-level pressure and departure from normal (both in millibars) for February 1960. The Pacific was not appreciably affected by blocking, but in the Atlantic note the large displacement of the Icelandic Low.

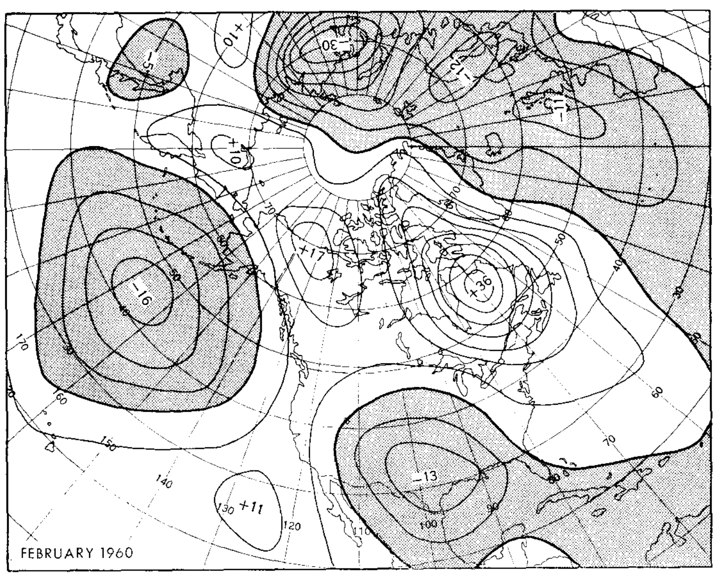

FIGURE 6.—Mean thickness (1000 to 700 mb.) departure from normal (tens of feet) for February 1960. There was a close correspondence between cooler than normal thickness and cooler than normal sea-level temperatures (fig. 2).

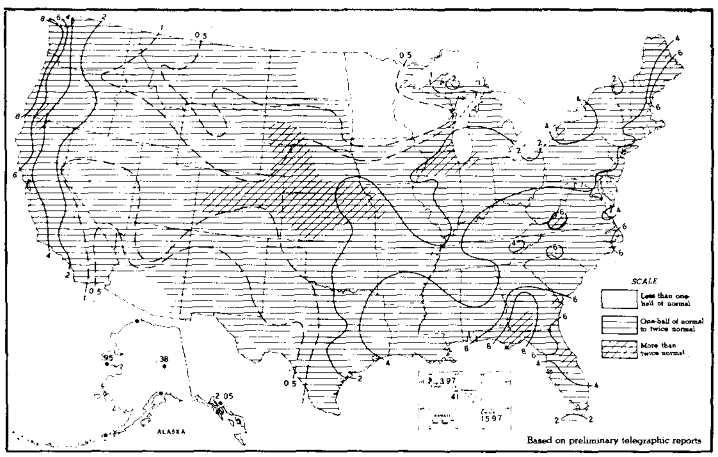

FIGURE 8.—Total precipitation (inches) for February 1960. Much of the precipitation east of the Rockies resulted from record and near-record snowstorms. (From [8].)

The cold portion of the United States was found where 700-mb. heights were generally less than normal and where upper level contours were cyclonic. The warm Northeast was also subject to a cyclonic flow, and since that flow was northwesterly, it would appear to have transported cold air into New England. However, 700-mb. heights were above normal and the DN flow was from an easterly direction, so that onshore advection of relatively warm air from the Atlantic was observed more frequently than normal during February. In fact this circumstance occurred much of the winter season.

The warm temperatures in the Northeast were an extremity of the greater picture which encompassed all the provinces and territories north of the Canadian border. There were no monthly mean temperatures below normal (except for extreme southern Saskatchewan) from Vancouver Island to Ellsmere Island and from Newfoundland to Point Barrow. The westward growth of anticyclogenesis in Canada was concurrent with the widespread warmth just described.

As expected, below normal values of monthly mean 1000 to 700-mb. thickness (fig. 6) practically coincided with below normal surface temperatures in the United

States. Similarly, above normal thickness attended above normal surface temperatures in North America. The +360-ft. center near Labrador was the maximum absolute value in the Northern Hemisphere. It was also the location of the maximum surface temperature anomaly (+24° F.) reported by the Canadian Meteorological Service.

Precipitation amounts exceeding 150 percent of normal (fig. 8) were generally confined to the Central Plains and to a strip from coastal New England to central Florida. In the East four storms west of the Appalachians and three east of the mountains were responsible for the record 27.6 inches of snow at Roanoke, Va., 21.5 inches at Charleston, W. Va., and 20.8 inches at Youngstown, Ohio.

In the Great Plains much of the precipitation can be attributed to overrunning initiated by a storm in north Texas early in the month. Another factor in the mean was cyclonic anomalous flow from an easterly direction at 700 mb. (fig. 3). Furthermore, there were 10 or 11 days with fronts from Montana to western Kansas as Pacific maritime air overran Canadian Polar air. February snowfall records were reported at Goodland, Kans., which had 25.4 inches, Kansas City, Mo., 20.7 inches, and Lincoln, Nebr., 19.2 inches.

Alaska recorded warmer than normal temperatures and normal or subnormal precipitation. The monthly mean temperature at Barrow averaged 9.6° F. above normal for February. A new maximum for the month was established on the 28th when the temperature rose to 32° F. On the same date the temperature at Yakutat reached a new February high of 49° F. Greatest mean temperature departure from normal was +12.0° F. at Kotzebue. The unusual warming over Alaska was related to above normal 700-mb. heights and southeasterly DN flow.

In the Hawaiian Islands temperatures were also rather extreme. Lihue reported a new maximum of 86° F. for February and a new all-time minimum of 53° F. At Honolulu 56° F. was a new low for the month. An all-time minimum of 55° F. was established at Hilo. The new records in the Hawaiian Islands were attained on those days when the normal trade wind regime was absent.

4. A TRANSITION AT MID-MONTH

CIRCULATION

The evolution of the circulation during February cannot be assessed solely from an inspection of the monthly mean charts. Half-monthly mean charts, shown in figure 9, depict clearly the great change which occurred in February, and emphasize its proportions.

First consider figure 9A, the 700-mb. mean for the 15-day period ending February 14. The trough in the central Pacific terminated in an intense Aleutian Low, which was 600 feet below normal. The ridge over North America was relatively weak. Although it was somewhat higher than normal in the United States, it was lower than normal in Canada. The trough downstream had fractured and was weak in the north, but quite deep in the south. Two severe storms deepened in the Southern Plains early in the month, en route to the eastern Great Lakes.

In the Atlantic the most important feature was the division of the westerlies into one branch northeastward from Labrador and the other eastward from the Middle Atlantic States. The height departures from normal show that blocking was firmly entrenched near Labrador, despite the cyclonic nature of the upper flow.

The circulation of the second half of February, shown in figure 9A, represents a drastic change from the first 15 days. Considering only major troughs in figures 9A and 9B, the readjustment of the circulation resulted in the following changes: (1) strengthening of the trough along the Asiatic coast; (2) demise of the trough in the mid-Pacific; (3) retrogression of the trough in the southern United States; (4) development of a new trough in the eastern Atlantic; and (5) effective loss of a trough in Eurasia.

As a result of these changes the hemispheric wave number was reduced by one. Considering both contours and height departures from normal, there were two major troughs at high latitudes and four at middle and lower latitudes in the first 15 days of the month. The wave number was reduced by one at both high and middle latitudes during the last 15 days of February.

In and near North America the change in height DN was of great magnitude and is accentuated graphically in figure 9C. The blocking in eastern Canada intensified by 560 feet and appeared to spread westward. The ridge which had been over the continent was located some 35° longitude to the west. It extended from the sub-tropics to the Polar Basin, the heights increased in the 2 weeks by 1,020 feet in the Gulf of Alaska. That was the largest change in the Northern Hemisphere, and its proximity to North America was of considerable importance to weather in the United States.

WEATHER

The weekly march of cold weather in February is described by the series of temperature departures from normal in figure 10, taken from [8]. For the week ending February 7 (fig. 10A), temperatures were above normal over most of the Nation, with a maximum of 18° F. in North Dakota. Acute cooling in the central portion of the United States in the second week (fig. 10B) followed the development of an intense cyclone which swept across the Rockies from eastern Colorado, where it intensified, to the central Lakes and into Canada (Chart X of [5]). Its passage in the Central and Southern Plains was accompanied by snow, strong winds, and record sea-level pressure for many stations. One of the lowest was 28.70 inches (972 mb.) at Ponca City, Okla. On the day prior to the storm, temperatures in the upper Rio Grande Valley reached as high as 102° F.; two days after the storm's passage, maximum temperatures were in the high 50's in that area.

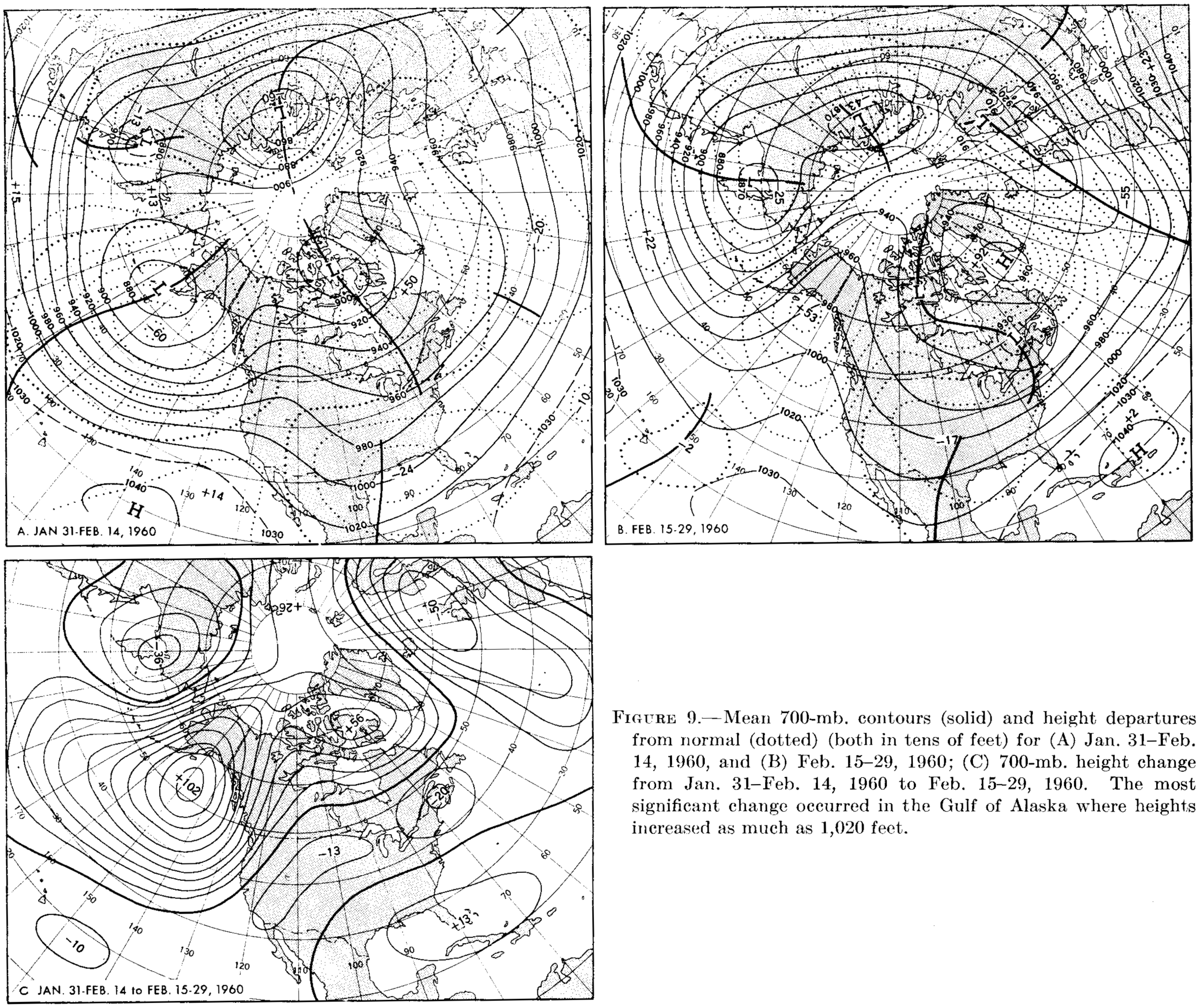

Figure 9.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for (A) Jan. 31–Feb. 14, 1960, and (B) Feb. 15–29, 1960; (C) 700-mb. height change from Jan. 31–Feb. 14, 1960 to Feb. 15–29, 1960. The most significant change occurred in the Gulf of Alaska where heights increased as much as 1,020 feet.

The consequences of the change in circulation over North America in the last two weeks of February were pronounced. Figure 9B indicates the strength of the great ridge in the eastern Pacific which propelled cold air into the United States. By the end of the third week (fig. 10C), weekly mean temperatures had dropped as much as 6° F. over a large part of the country. A storm which developed over southeastern Texas on the 17th deepened rapidly as it traversed the Gulf States, crossed the Middle Atlantic States, and moved into the Bay of Fundy. In its wake was a broad band of heavy snowfall from the central Mississippi Valley to the Maritime Provinces.

The continued rise in 700-mb. heights in northwestern North America favored severe cold in most of the United States. The strong northwesterly flow from the Beaufort Sea to the Rocky Mountain States (fig. 9B) was responsible for a prolonged outbreak of Arctic air into the United States. In figure 10D, week ending February 28, temperatures averaged below normal in most of the United States. Mean temperatures more than 20° F. below normal were observed from northern Texas to Montana. Rather weak storms in the southern and central portions and one major storm in the East were responsible for as much as 16 inches of snow in Kansas and lesser amounts to the east.

In all instances just discussed (fig. 10) the most per-

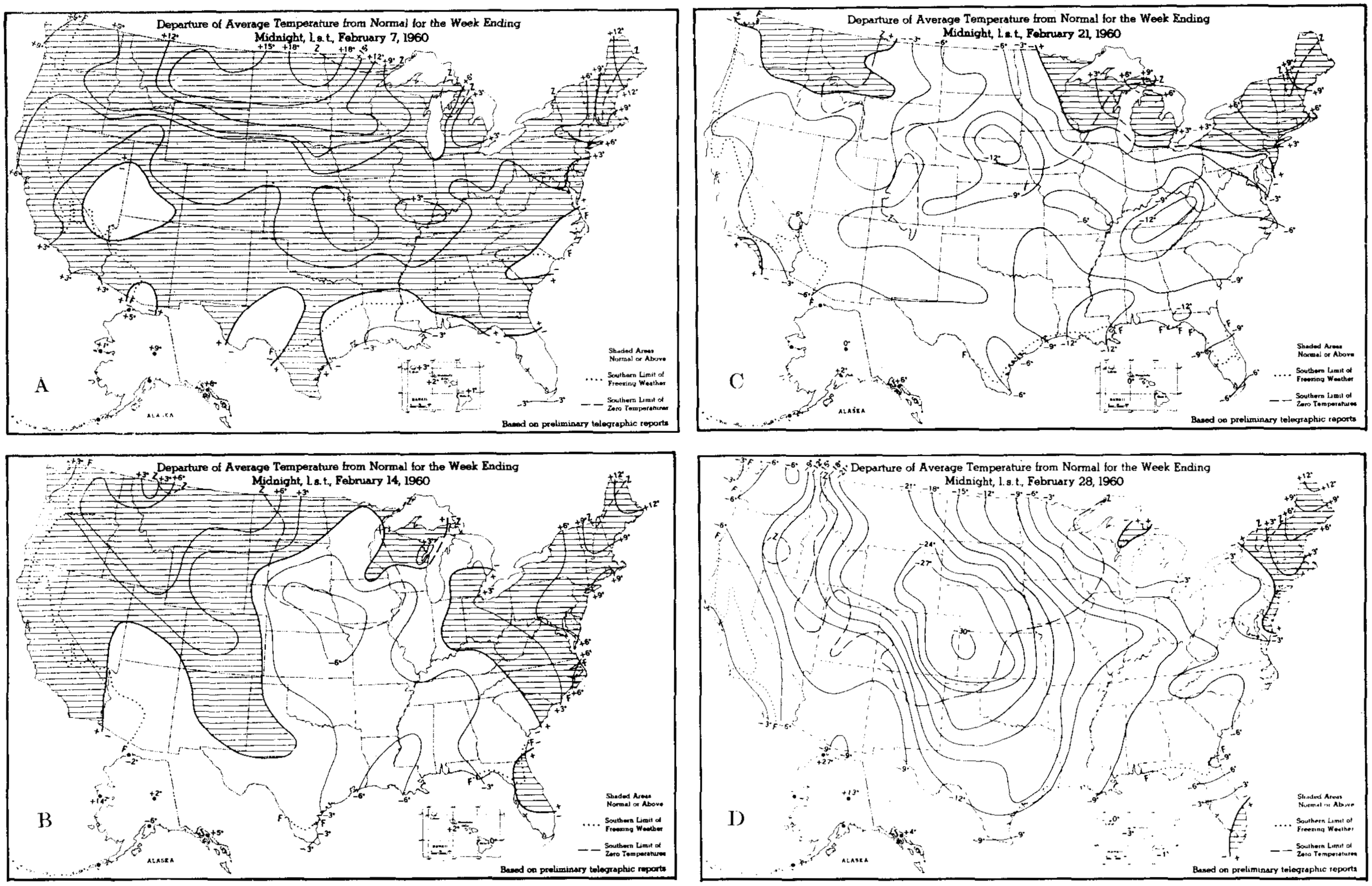

FIGURE 10.—Departure from normal of average temperature (°F.) for weeks ending (A) Feb. 7, 1960, (B) Feb. 14, 1960, (C) Feb. .21 1960, and (D) Feb. 28, 1960. After the mild first week, temperatures over a large area became progressively colder. (From [8]).

sistent feature common to all weeks was the warmth in the Northeast. In New England temperatures averaged from 6 to 12° F. warmer than normal each week. This area was influenced by mild Atlantic air under the blocking regime. Thus, while other regions of the country were experiencing cold weather in February, it was an exceptionally mild month in New England.

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